A HAND BOOK TO THE WAXED PAPER PROCESS IN Photography

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PREFACE.

THE general outline of the following Work is founded on the "Deſcription of the Waxed Paper Proceſs employed for the Photometeorographic Regiſtrations at the Radcliffe Obſervatory," a paper which forms a ſupplement to their volume of obſervations for the year 1854.

Having been occupied for ſome time in ſuperintending and arranging the meteorological department of the above obſervatory, I was, on leaving, requeſted by the talented obſerver, M. J. Johnſon, Eſq., to place on record for the benefit of their ſtaff a deſcription of the photographic proceſs which I had ſo ſucceſsfully introduced for recording the

obſervations in their meteorological inſtruments: viz. the Barograph and Thermograph of Mr. Ronald's conſtruction, and a Pluviograph deſigned and made by myſelf.

The experiments which I found it neceſſary to undertake, ere I arrived at the above reſults, occupied my unremitting attention for upwards of a twelvemonth, and were conducted on a ſcale commenſurate with the great importance of the object which I had in view.

A vaſt number of the facts thus brought under my notice relate to points of chemical, optical, and photographical ſcience which are alike common to every branch of the Art. Some few, neceſſarily, apply merely to the eſpecial purpoſe which then engaged my attention; whilſt others are only applicable to the Waxed Paper Proceſs for the ordinary requirements of the photographer.

Latterly I have occupied myſelf in extracting from theſe innumerable data, materials wherewith to build a proceſs which I can con-

fidently preſent to my readers as poſſeſſing many advantages over thoſe in general uſe. In the following pages the ſeveral operations in the Waxed Paper Proceſs are moſt minutely deſcribed, and I venture to ſay, that any perſon who is at all converſant with the ordinary manipulations required in photography, will, by carefully following theſe directions, at once meet with ſucceſs.

WILLIAM CROOKES.

CONTENTS.

Contents.

THE WAXED PAPER PROCESS IN PHOTOGRAPHY.

THE Waxed Paper Proceſs appears to me to be more particularly applicable to the ordinary requirements of the touriſt or amateur in general than any other paper proceſs whatever. The various operations, though numerous and at firſt ſight rather complex, are of ſuch a kind as to be eaſily reducible to practice, ſo that I believe average reſults can be obtained by this method with a ſmaller ſhare of manipulatory ſkill than is required in moſt other paper proceſſes.

In ſharpneſs it may be made to rival Collodion, and though it cannot approach the latter in its exquiſite ſenſitiveneſs, it will give place in this point to none of the ordinary modifications of the Calotype Proceſs. Its

chief ſuperiority, however, conſiſts in its capability of remaining ſenſitive for ſo long a time that it is of little conſequence whether the ſenſitive ſheets be a day or a week old. Then the comparative ſlowneſs of the development, which is generally looked upon as one of its weak points, may juſt as fairly be called a poſitive advantage, as it diſpenſes with that care and attention which muſt always be beſtowed upon a quickly developing picture.

2. The Waxed Paper Proceſs does not materially differ in principle from the original Calotype: iodide of ſilver is formed by double decompoſition on, or rather in, the pores of a ſheet of paper. This iodide is made ſenſitive to light by means of a ſlight exceſs of nitrate of ſilver; and, after expoſure, the decompoſition commenced by the light is continued by bringing the iodide of ſilver in contact with a mixture of nitrate of ſilver and a reducing agent, ſuch as gallic acid; and, eventually, the unreduced iodide is diſſolved away from the metallic ſilver by hypoſulphite of ſoda or ſome other convenient ſolvent.

In the Calotype Proceſs the principal difficulty is, the ſelection of a good, well ſized,

and compact paper; for unleſs this be exceedingly good in quality, the ſize is liable to be diſſolved out during the numerous waſhings to which it is ſubjected. This renders it not only difficult to handle without tearing, but, by allowing the chemicals to ſink into the paper whilſt the cement which bound the fibres together has been removed, tends to produce a rough, indiſtinct appearance in the outlines of the picture.

3. To obviate this difficulty it was propoſed by Legray to ſtop up the pores of the paper with wax, and by this means convert the ſoft ſpongy material into a hard impervious medium like parchment. Long ſoaking in a ſolution of iodide of potaſſium, or ſlightly waſhing in a weak ſolution of iſinglaſs in water, will remove the greaſineſs from the ſurface, and then moſt beautiful pictures can be obtained on it either by Talbot's original formula, or, as is more generally employed, by that modification of it which has been found moſt ſuitable to paper of French manufacture.

4. The ſeveral operations in the Waxed Paper Proceſs may be conveniently divided into ſix parts: viz. waxing, iodizing, exciting,

expoſing, developing, and fixing: but before entering into the practical details of theſe operations it may not be without ſervice if I give a ſhort deſcription of ſome of the apparatus which is more particularly required in this proceſs, together with a few remarks on the chemicals, &c. which are in moſt frequent uſe.

5. In this, and in fact in every other photographic proceſs, the means adopted for illuminating the ſo-called dark room is of the firſt importance.

The reſults of ſome very numerous experiments, tried during the ſpring and ſummer of 1853,* ſatisfied me that the rays which were active on iodide or bromide of ſilver have a fixed and definite boundary line in the ſolar ſpectrum; conſequently, in the ſelection of a tranſparent illuminating medium for the window of a photographic laboratory, it is a deſideratum to find one which may admit abundance of light, and ſtill filter off, as it were, theſe chemically acting ſpectral rays.

6. When iodide of ſilver is expoſed to a pure ſpectrum for a ſpace of time inſufficient

* Vide Photographic Journal, vol. i. p. 100.

to darken it visibly, and then the image brought out by a developing agent, it is only affected by the rays more refrangible than $\frac{1}{6}$GH* forming the indigo, violet, and invisible part of the spectrum, the maximum effect being between $\frac{1}{6}$GH and H k1, comprising the indigo and lower two-thirds of the violet. On

* When referring to any point in the solar spectrum not corresponding with one of Frauenhofer's fixed lines, I adopt the nomenclature given by Professor Stokes in his paper (Phil. Trans. 1852, part II. article 24). I cannot describe it better than in his own words:—

"The position of a point in the spectrum which does not coincide with one of the principal fixed lines, will be denoted by referring it to two of those lines, in a manner which will be most easily explained by an example. Thus $\frac{1}{2}$G H, G $\frac{1}{2}$H, G H $\frac{1}{2}$ will be used to denote respectively a point situated at a distance below G equal to half the interval from G to H, a point midway between G and H, and a point situated at the same distance above H. In using this notation, the letters denoting fixed lines will be written in the order of their refrangibility, and the fraction expressing the part of the interval between these lines, which must be measured off in order to reach the point whose position it is required to express, will be written before, between, or after the letters, according as the measurement is to be taken from the first line in the negative direction, from the first line in the positive direction, or from the second line in the positive direction, the positive direction being that of increasing refrangibility."

replacing the iodide of ſilver by bromide of ſilver, the reſult ſhows equally concluſively the exiſtence of a definite boundary line of action, the darkening being produced only by the rays above the band *b* (between E and F) forming three quarters of the green, together with the blue, indigo, violet, and inviſible ſpaces, the maximum being between *b* and H k 1, compriſing three quarters of the green, the blue, indigo, and two-thirds of the violet.

7. Theſe reſults ſhow how unſafe and imperfect an illuminating medium yellow calico is for ſuch a purpoſe. One thickneſs, it is well known, allows white light to paſs; conſequently an increaſe in the number of folds merely diminiſhes the amount of tranſmitted white light, and in the ſame degree obſtructs the illuminating yellow light.

8. On examining ſome pieces of glaſs of different colours with the ſpectrum, I found ſeveral which would anſwer the purpoſe. From theſe I picked out one of a deep orange colour, as being the more ſuitable. It was perfectly opaque to rays above Frauenhofer's line E (from the green upwards), but tranſmitted the lower luminous rays with facility. I had

a piece of the glaſs, nearly a foot ſquare, fitted into the ſhutter of my room, and although during one part of the morning the ſun uſed to ſhine directly through it on to the glaſs bath (uncovered) in which perhaps a collodion plate was being excited, I could not trace a ſingle failure to this cauſe; and while, in point of ſecurity, it was at leaſt equal to four or five thickneſſes of yellow calico, it was incomparably more pleaſant to work by, as when the ſun was ſhining, the darkeſt corners of the room were illuminated as if by daylight.

MATERIALS EMPLOYED IN THE PROCESS.

THE following is a liſt of the materials which will be found either neceſſary or uſeful in the proceſs:—

Several diſhes.
Bruſhes for cleaning ditto.
Veſſel for melting wax.
Lamp furnace.
Box iron.
Still for water.
Platinum ſpatula.
Funnels and ſtand.
Several meaſure glaſſes, from 1 drachm to 1 pint.
Glaſs flaſks.
Scales and weights.

Sponge, glaſs rods, ſtoppered bottles, &c.
Photographic paper.
Blotting and filtering paper.
Wax.
Iodide of Potaſſium.
Milk Sugar.
Nitrate of Silver.
Acetic Acid.
Gallic Acid.
Alcohol.
Hypoſulphite of Soda.
Cyanide of Potaſſium.
Nitric Acid.
Diſtilled Water.

10. The diſhes may be made of glaſs, porcelain, or gutta percha. Glaſs and porcelain are certainly cleaner than gutta percha; but for general uſe the latter is far preferable, as with it there is no riſk of breakage, and the bottom of the diſh can be made perfectly flat, which is a great advantage. They ſhould be of a ſufficient ſize to allow of about half an inch margin round the ſheet of paper. The gutta percha ſhould be of a good thickneſs, otherwiſe it will bend and give way, if it be moved when full of liquid. The depth muſt

depend upon the ſize of the diſh, and the purpoſe for which it is intended; for ordinary work a very good rule is to make the depth a tenth part of their diagonal meaſure acroſs, but for the iodizing or fixing baths they ſhould be double the above depth, or one fifth. Each diſh ought to be reſerved for a particular ſolution, and ſhould have for a cover a piece of mill board a little larger than itſelf.

11. The bruſhes for cleaning the diſhes are of two ſorts; a common ſcrubbing bruſh will be found the beſt for all parts but the corners, and for theſe another kind muſt be uſed, having a handle about a foot long, at the end of which are tufts of ſtiff briſtles, projecting about three quarters of an inch, and radiating on all ſides, forming a ball about two inches and a half in diameter. Hardly any dirt will be found capable of reſiſting this bruſh, if it be preſſed into a corner, and twiſted round ſeveral times. The diſhes ought always to be put away clean, as the dirt is much more difficultly removed if allowed to dry on.

12. When a diſh is to be cleaned, if it be of glaſs or porcelain, ſtrong nitric acid muſt

be poured into it; if of gutta percha, it ſhould be filled with a ſtrong ſolution of cyanide of potaſſium. After ſoaking for half an hour or an hour, according to the ſtate of the diſh, the liquid is to be returned into the bottle, (both the nitric acid and the cyanide can be uſed ſeveral times,) the diſh rinſed out with water, and then well ſcrubbed in every part with the bruſhes; afterwards it is to be waſhed ſeveral times in common water, once with diſtilled water, and then placed in a ſlanting poſition againſt a wall, face downwards, to drain on clean blotting paper.

13. The veſſel in which the wax is melted, muſt be contrived ſo as never to allow of its reaching a higher temperature than 212° Fahr., or decompoſition of the wax might enſue. I have found the moſt convenient apparatus to be a tin or copper veſſel, of a ſufficient ſize to allow a ſheet of paper to lay looſely in it, and 4 inches deep, having a tray which holds the wax fitting into it about 1 inch deep. The under veſſel is to be half filled with water, and by keeping this at the boiling temperature, the wax above will ſoon become liquid.

14. If gas is not conveniently attainable,

the water may be heated either by an oil lamp furnace, or ſpirit lamp: but otherwiſe the beſt ſource of heat is that known as the gauze gas burner, it being free from ſmoke or duſt, and not liable to blacken anything placed over it. It conſiſts of a common argand burner fixed on a rather low and heavy iron ſtand, which is ſurmounted by a copper or braſs cylinder 5 inches in height and 2 inches wide, having a piece of wire gauze of 900 meſhes to the ſquare inch faſtened over the top. By connecting this burner by means of vulcaniſed indian-rubber tubing to the gas pipe, it can be moved about the table to any convenient poſition. The mixture of gas and air formed inſide the cylinder, is to be lighted above the wire gauze; it burns over this with a large and nearly colourleſs but intenſely hot flame.

15. The moſt convenient form of iron is the ordinary box iron, made hot by heaters inſide; I decidedly give preference to that moſt reſembling the common flat iron in ſhape: it ought to be tolerably heavy. Some operators recommend facing the bottom with a plate of ſilver; this is very expenſive and

ſeems to me to be attended with no advantage whatever.

16. The diſtilled water being one of thoſe ſubſtances upon the purity of which ſucceſs will in a great meaſure depend, it will be found much ſafer to diſtil it on the premiſes, eſpecially as the quantity required is trifling. A convenient ſize for the ſtill is about two gallons; it may be procured ready made, with worm, &c. complete, of any large dealer in chemical apparatus. The moſt convenient ſource of heat is that deſcribed above (14).

17. A platinum ſpatula is a moſt neceſſary inſtrument in almoſt every operation; the beſt ſize is 4 inches long, $\frac{1}{2}$ an inch wide at one end, and $\frac{3}{8}$ at the other, the corners being rounded off; it ſhould be of a ſufficient ſubſtance to prevent its being eaſily bent. Its chief uſe is, to raiſe one corner of the ſheets to allow of their being held between the finger and thumb, for the purpoſe of removing from one diſh to another, as, previous to fixing, neither the ſurface of the ſheet, nor any of the ſolutions ſhould come in contact with the fingers.

During the fixing and ſubſequent waſhing,

bone ſpatulas will be found very uſeful; but after having been in contact with hypoſulphite of ſoda they muſt be carefully kept away from any of the previous ſolutions, or black ſtains will inevitably enſue.

18. The funnels may be either of glaſs or porcelain: it will be found uſeful to have them of different ſizes, from 2 inches diameter up to 6 inches. A convenient ſtand for them may be made of a piece of flat board, with circular holes about half the diameter of the funnels employed, drilled into it, and ſupported upon four legs about 8 inches high. The paper uſed for filtering ſhould be the fineſt of the two ſorts of blotting paper mentioned below (21). The filters can either be cut from the ſheet as wanted, or they may be obtained ready cut in packets.

The meaſures ſhould be of glaſs, graduated, the pint and half pint into ounces, the ounce meaſure into drachms, and the drachm meaſure into minims: they ſhould be rather long in proportion to their width.

19. The Florence oil flaſks, which can be obtained for a trifle at any oil warehouſe, will be found to anſwer every purpoſe, nearly as

well as the more expenſive German flaſks. They muſt be cleanſed thoroughly from the adhering oil; this may be done by boiling in them, over the gauze gas burner, a ſtrong ſolution of ordinary waſhing ſoda, and afterwards well rinſing out with water.

The ſcales and weights need not be of any great accuracy. A ſix inch beam capable of turning to half a grain, when loaded with 500 grains in each pan, will be all that is requiſite; the pans muſt be of glaſs, and the weights ſhould conſiſt of a ſet of grain and a ſet of drachm weights.

A ſponge will be found uſeful for wiping up any of the ſolutions that may have been ſpilt on the bench. Solid glaſs ſtirring rods, of about the thickneſs of a quill and ſix or eight inches long, and a ſmall Wedgwood peſtle and mortar are of great ſervice in many of the operations.

Stoppered bottles ſhould be employed for all the ſolutions; and too much care cannot be taken to label each bottle accurately and diſtinctly.

20. The ſelection of a good ſample of paper for the baſis on which the ſenſitive material is

to be formed is of great importance, as any imperfection will be a ſource of annoyance in every ſtage of the proceſs, and will hardly fail to ſhow itſelf on the finiſhed picture. The paper which from numerous experiments I have found to be ſuperior to any other, is Canſon's thin photographic paper. In looking over a ream of this paper, a few quires may generally be picked out of an extra thinneſs, and at the ſame time extremely hard and cloſe grained: if the operator have it in his power, I ſhould decidedly recommend that the paper ſhould be looked over in this way, and only theſe ſheets be reſerved for this proceſs; at the ſame time it muſt be remembered that the difference is hardly ſufficient to make it a matter of material conſequence.

21. The blotting paper ſhould be of two kinds; namely, the ordinary white wove, for the purpoſe of abſorbing the exceſs of wax from the ſheets during the operation of ironing (30); and the fine filtering paper (not the Swediſh) employed in quantitative chemical operations, which muſt be employed for drying the ſenſitive ſheets and for filtering.

22. As an article of commerce it is very

difficult to obtain ſmall quantities of wax ſufficiently pure to be relied upon. It will be unſafe to uſe that which is uſually met with in the form of thin round cakes about 4 inches in diameter, as in this ſtate it is generally adulterated to the extent of *at leaſt* 50 per cent.

If the makers were to confine their adulteration to ſpermaceti, as I believe they profeſs to do, it would not be of very much conſequence; but as the price of the latter does not differ very much from that of pure wax, it is not ſo common an adulteration as other cheaper ſubſtances; e.g. Stearin, Stearic Acid, Tallow, Roſin, Plaſter of Paris, &c. &c., which, as may be ſuppoſed, have a moſt injurious effect. The only way I can recommend is to apply to ſome large firm of known reſpectability, and truſt to them for ſupplying it in a ſtate of purity.

23. Through the kindneſs of ſeveral friends, amongſt whom I may mention Mr. Barclay of Regent Street, and Profeſſor Maſkelyne of Oxford, I am indebted for much valuable information concerning wax and its adulterations, and for an extenſive aſſortment of waxes

of all kinds and in every degree of purity, together with a valuable ſeries of the chemical bodies of which the various waxes are compoſed; by means of theſe, I have been enabled to examine the effect produced by ſaturating the paper with Bees' wax from different countries, Myrica wax, Canauba wax, China wax, Spermaceti, Ethal, Stearin, Stearic acid, Palmitin, Palmitic acid, Paraffin, and various oils.

24. I find that the action of the wax is purely mechanical, almoſt the only difference of effect produced by any of the above bodies, widely as they vary in their chemical nature, ariſing from a difference in their phyſical properties.

Stearin, Palmitin, and moſt of the oils, are too greaſy in their nature to be advantageouſly employed. The fatty acids do not make the paper in the leaſt greaſy, but they injure the tranſparency. China wax has almoſt too high a melting point, and gives a cryſtalline ſtructure to the paper. Spermaceti alſo is too cryſtalline. Paraffin, Ethal, and the waxes, produce very good reſults; of theſe Bees' wax is the only one that would be practically available for this purpoſe. It ſhould be free from

Stearin, Stearic acid, Tallow, &c.; the preſence of a little Spermaceti, or the beſt olive oil, does not much interfere, and in fact an addition of the latter in ſmall quantities is a ſlight improvement in cold weather, as it tends to lower the fuſing point of the wax. Too much muſt be avoided, as it then makes the paper greaſy.

25. The other chemicals, (with the exception of the ſtrong nitric acid, which any retail druggiſt will ſupply, and the water, which had beſt be diſtilled on the premiſes,) ſhould be ordered direct from ſome large manufacturer of photographic chemicals, as otherwiſe, unleſs the operator have a ſufficient knowledge of chemiſtry to be able to detect any inferiority, there is danger of not having the articles ſufficiently pure.

The nitrate of ſilver ſhould be cryſtallized, not in ſticks; it ought to be perfectly dry, and have no ſmell, acid or otherwiſe.

There are uſually two varieties of glacial acetic acid to be met with; the pureſt muſt be uſed; it ſhould be perfectly free from any empyreumatic odour, and muſt cauſe no turbidity when mixed with a ſolution of nitrate of ſil-

ver, e. g. in making the exciting bath (51).

The gallic acid ſhould be as nearly white in colour as poſſible.

Eſpecial care ſhould be taken to have the alcohol good; it ſhould be 60° over proof, and of ſpecific gravity 0.83. On evaporating a few drops on the palm of the hand, no ſmell ſhould be left behind, nor ſhould it, under the ſame circumſtances, leave any ſtain on a ſheet of white paper.

26. The hypoſulphite of ſoda will be found one of the articles moſt difficult to obtain pure; there is a large quantity at preſent in the market, having little elſe of this ſalt but the name, and is of courſe totally unfit for uſe; if there be the leaſt doubt about its purity, it ſhould be teſted in the following manner:—

Weigh out accurately 10 grains of nitrate of ſilver, diſſolve this in half an ounce of diſtilled water; then add 4 grains of chloride of ſodium (common ſalt) alſo diſſolved in water. On mixing theſe two ſolutions together, a white curdy precipitate of chloride of ſilver will fall down. Next add 22 grains of the hypoſulphite of ſoda, and allow it to ſtand for about ten minutes, ſtirring occaſionally

with a glaſs rod. If at the end of that time the chloride of ſilver has diſſolved, the hypoſulphite of ſoda may be conſidered as pure. A greater or leſs amount of reſidue will indicate roughly the degree of impurity.

27. The cyanide of potaſſium is uſually met with in the form of hard white lumps; they will be found quite pure enough. It is very uſeful in removing ſtains formed by nitrate of ſilver on the fingers, &c. but the greateſt care muſt be taken in its employment, as it is a moſt energetic poiſon; its uſe in cleaning the diſhes from ſilver ſtains has been pointed out above (12).

WAXING AND IRONING.

THE firſt operation to be performed is to make a ſlight pencil mark on that ſide of the photographic paper which is to receive the image. If a ſheet of Canſon's paper be laid on a ſmooth table near a window, and examined from the diſtance of a few feet, one of its ſides will be ſeen to have parallel bands running acroſs it, alternately light and dark, and about one inch wide; if it now be examined cloſer, this ſame ſide will be found to preſent a finely reticulated appearance, ſimilar to linen, eſpecially at the corners, the other ſide being perfectly ſmooth; this latter is the ſide that ſhould be marked. Either of theſe methods may be uſed; the former will be found more convenient for large ſheets, and the latter for ſmall ones.

29. The paper has now to be ſaturated with wax. The apparatus for this purpoſe has been previouſly deſcribed (13). The under veſſel is to be half filled with boiling water, and this kept boiling by placing one of the abovementioned ſources of heat (14) under it. The heat from the water communicates itſelf to the wax, which ſoon becomes liquid, and then the ſheets of paper, taken up ſingly and held by one end, are to be gradually lowered on to the fluid. Very little care is required in this operation, even encloſing a few ſmall air bubbles is immaterial, as the act of lifting the ſheet up will generally cauſe the fluid wax to flow over the vacant ſpace. As ſoon as the wax is abſorbed, which takes place almoſt directly, one corner is to be raiſed by means of the ſpatula (17), taken between the finger and thumb, and then lifted up with rather a quick movement: the ſheet muſt now be held by the corner and allowed to drain until the wax, ceaſing to run off, congeals on the ſurface.

When the ſheets are firſt taken up for this operation they ſhould be briefly examined, and ſuch as ſhow the water mark, contain any

black ſpots,* or have anything unuſual about their appearance, ſhould be rejected.

30. The paper in this ſtage will contain far more wax than neceſſary; the exceſs may be removed with very little waſte by ironing them in the following manner:—Firſt place on a ſmooth table about a dozen ſheets of blotting paper (waſte paper from previous operations will do ſufficiently well) a trifle larger than the photographic paper; then on this pad lay a ſheet of clean blotting paper (21), then two ſheets of plain photographic paper, next one of the ſheets which has been ſaturated with wax (29), over this two other plain ſheets, and laſtly a piece of clean blotting paper.

If a hot iron (15) be now paſſed over the whole ſeveral times, it will be found that gradually the wax from the centre ſheet will ſoak through the two upper ſheets of paper, and completely ſaturate them; and on turning over the pile of five and repeating the ironing,

* Theſe ſpots have been analyzed by Mr. Malone; he finds them to conſiſt, not of iron, as is generally ſuppoſed, but of ſmall pieces of braſs. I have alſo examined them myſelf with a like reſult.

the other two ſheets will become ſaturated. When this has taken place the waxed ſheets muſt be ſeparated one from the other, and laid on one ſide for the ſecond ironing; while another pile can be waxed in the ſame way, uſing the ſame blotting paper, and ſo on until as many ſheets as are needed have been once under the iron. Finally, each ſheet muſt be ſeparately ironed between clean blotting paper, until there are no gliſtening patches of wax to be ſeen on the ſurface.

31. For ironing the paper the firſt time, the temperature of the iron ſhould be ſuch that a drop of water allowed to fall on it will boil rapidly, but not roll off; but before the iron is uſed for paſſing over the waxed ſheets the ſecond time, it ſhould be dipped into water until the hiſſing entirely ceaſes, as it is of the utmoſt conſequence that its temperature ſhould not exceed that of boiling water.

This is one of the moſt important points in the whole proceſs, but one which it is very difficult to make beginners properly appreciate. The diſadvantages of having too hot an iron are not apparent until an after ſtage, while the ſaving of time and trouble is a great

temptation to beginners. It is to a neglect of this point that I am inclined to attribute moſt of the faults ſo commonly laid to the charge of this beautiful proceſs; ſuch as gravelly appearance, or want of ſmoothneſs in the lights, and quick decompoſition in the developing ſolution.

32. A well waxed ſheet of paper, when viewed by obliquely reflected light, ought to preſent a perfectly uniform glazed appearance on one ſide, while the other ſhould be rather duller; there muſt be no ſhining patches on any part of the ſurface, nor ſhould any irregularities be obſerved on examining the paper with a black ground placed behind; ſeen by tranſmitted light, it will appear opaleſcent, but there ſhould be no approach to a granular ſtructure. The colour of a pile of waxed ſheets is ſlightly bluiſh.

IODIZING.

THE paper, having undergone this preparatory operation, is ready for *iodizing*; this is effected by completely immerſing it in an aqueous ſolution of an alkaline iodide, either pure or mixed with ſome analogous ſalt.

One would think that in no part of the photographic operation would greater unanimity exiſt, than on the compoſition of the iodizing bath; but on this ſubject, ſtrangely enough, no two perſons ſeem to think alike. The formulæ for this bath are nearly as numerous as the operators themſelves, and ſome of them ſhow not a little ingenuity in the manner in which ſubſtances apparently the moſt unphotographic have been preſſed into ſervice; but, notwithſtanding the formidable

mixtures of organic and inorganic bodies which it is the faſhion amongſt photographers to crowd into this bath, as if complexity were all that was wanted, I am ſtill of opinion that the ſimpler the bath is the better; indeed, I can ſcarcely imagine the uſe of a photographer troubling himſelf much about the purity of his chemicals, when inſtead of diſtilled water being the ſolvent, he uſes London milk.

34. In all paper proceſſes there are certain conſtant reſults which I have found attendant on the uſe of iodide of potaſſium and its analogues.

One of the difficulties moſt frequently complained of is what is termed *ſolarization*; i. e. the deſired opacity of the more highly illuminated parts of the picture are loſt by over expoſure, and give place to a tranſlucent red colour. This is a great inconvenience, for as it is always deſirable that every object, even thoſe in deepeſt ſhadow, ſhould produce a correſponding impreſſion on the paper, it becomes neceſſary, in order to ſecure theſe, to prolong the expoſure for ſuch a time as to riſk the loſs of the brighter parts.

35. I find that when pure iodide of ſilver

is the ſenſitive material, there is very little likelihood of the ſky, or other light parts of the picture, becoming red, even after a very prolonged expoſure; but the addition of a ſmall proportion of a bromide, chloride, fluoride, or cyanide, is ſufficient to give it this objectionable tendency.

I will not deny that a much greater degree of ſenſitiveneſs may be obtained when a ſmall proportion of bromide of potaſſium, or chloride of ſodium, is uſed in addition to the iodide; but I much prefer to ſubmit to the ſlight inconvenience of waiting a few minutes longer, during the time of expoſure, when the reward is the permanent gratification afforded by having a ſuperior and more truthful negative than could have been otherwiſe obtained.

36. A great deal has been ſaid, and written, about the ſuperior ſenſitiveneſs to coloured light, which is obtained by employing bromide of ſilver inſtead of iodide; founded on ſome experiments by Sir J. F. W. Herſchel, publiſhed in the Phil. Tranſ. (1840, article 77), where he ſtates that the action of the ſolar ſpectrum on a paper prepared with bromide of ſilver, commences, "the moment the

rays fall upon it, viſibly over its whole length, and is uniform in intenſity at every point, except juſt at the extremities."

Now, as this effect was produced at once, and without any after application of a reducing agent, whilſt in a camera picture the firſt effect of the light is generally inviſible, requiring development to render it apparent, it becomes evident that any inference which may be drawn from the above experiments, cannot apply to the preſent practice of photography, unleſs the ſame ſpectral rays which, by a comparatively long action, will produce a viſible darkening on bromide of ſilver, are alſo capable of producing a latent action on the ſame ſenſitive ſurface, which may be continued and rendered ſenſible by means of a developing agent.

37. That this is not the caſe is evident from a compariſon between the reſult obtained by Sir J. Herſchel (36), and my own experiments alluded to above (6), where I ſhow that whilſt iodide of ſilver is not acted on by the red, orange, yellow, green, or blue rays; bromide of ſilver is alſo inſenſible to the red, orange, yellow, and part of the green rays.

38. From theſe reſults it might, however,

ſeem that although for copying moſt coloured objects, bromine was as valueleſs as iodine, yet for vegetation, and other green objects, there would be a marked difference in favour of the former. This, however, is not the caſe. There is reflected from green vegetation ſuch a maſs of rays which equally affect bromide and iodide of ſilver, that the action of the narrow band of rays in which the former ſhows its ſuperiority is unnoticed: and when it is remembered that, in paper proceſſes, to employ bromides at all, there muſt be a large exceſs of an iodide, even this ſlight advantage diſappears, and the much talked of ſuperiority of bromine over iodine for copying colour is ſeen to be founded upon a too limited knowledge of the ſubject.

39. During the courſe of my experiments on this point, for the Radcliffe Obſervatory, ſeveral beautiful and inſtructive facts were brought under my notice, and as they throw much light upon the theory of this part of the proceſs, and point out the neceſſity of varying the compoſition of the ſenſitive ſilver ſalt to ſuit the kind of light employed, I am induced to mention them rather in detail here, in the

hopes that others will purſue this intereſting enquiry.

40. The reſults of the experiments above referred to (35) had convinced me, that for ordinary purpoſes iodide of ſilver *per ſe* was the beſt ſenſitive ſurface for receiving an image in the camera; but on making uſe of that body for the purpoſe of receiving the image in the meteorological inſtruments, (by employing pure iodide of potaſſium in the bath,) I was ſurpriſed to meet with reſults, for which I was at firſt unable to account. A little conſideration, however, ſhowed me the direction in which I was to look for a remedy. The experiments which had led me to prefer iodide of ſilver as a ſenſitive ſurface, had all been performed with ſunlight, either direct or more frequently in the form of diffuſed daylight. In this caſe, however, coal gas was the ſource of light; and if, as was very probable, there were any great difference in the quality of the light from theſe two ſources, the ſuperiority of iodide over the bromide or chloride of ſilver would ſtill be a matter for experiment.

41. A compariſon of the ſpectra of the two kinds of light ſhowed a very marked differ-

ence; while in ſunlight the ſpectral rays which are around and above the fixed line G (the indigo and higher rays) are ſo intenſe and numerous as completely to overpower the ſmall ſpace between and about F and G (the blue and upper portion of the green), a part of the ſpectrum which affects bromide more than iodide of ſilver; in gas-light the caſe was quite different: the great bulk of photographic rays was found to lie within the limits of the viſible ſpectrum, and conſequently the photographic action of this light was likely to be far more energetic on bromide than on iodide of ſilver.

42. Theſe ſuppoſitions were fully borne out by experiment: on introducing a little bromide of potaſſium into the iodizing bath, the change was very apparent. It required a certain proportion to be obſerved between the two to obtain the beſt reſults: if the iodide of potaſſium were in exceſs, the reſulting ſilver ſalt was wanting in ſenſitiveneſs, requiring a comparatively long development to render an image viſible; while, if the bromide were in exceſs, there was a great want of vigour in the impreſſion, the picture being red and tranſ-

parent. When the proportion between the two was properly adjuſted, the paper was extremely ſenſitive, the picture preſenting a vigorous black appearance, without the leaſt approach to red. I found that the beſt reſults were obtained on mixing the iodide and bromide of potaſſium in the proportion of their atomic weights.

43. The iodizing bath that I have found to give the moſt uniform and vigorous negatives, when the objects are illuminated by ſun or daylight, is made in the following manner:—

Take

Iodide of Potaſſium	1000 grs.
Iodine . .	10
Diſtilled Water .	1 quart

Diſſolve the iodide of potaſſium in a few ounces of the water, and then add the iodine. As ſoon as it has diſſolved, which it will readily do if it be ſtirred about, add the reſt of the water, and the bath will be fit for uſe.

44. This bath will remain good to the laſt drop: it will, however, require to have iodine added to it in ſmall quantities from time to time. This will be moſt conveniently done

by taking about half a pint of the bath, in a ſeparate bottle, and adding to it a great exceſs (ſay a quarter of an ounce) of iodine: this will render the ſupernatant liquid nearly black and whenever the bath requires replenifhing with iodine, a few drops of the above ſtrong ſolution will ſuffice to bring it to the proper colour, which ſhould be that of pale ſherry.

This ſolution muſt be poured, or filtered, if neceſſary, into a rather deep diſh (10) and then the waxed and ironed ſheets are to be completely immerſed in it, in the proportion of twelve or fourteen ſheets of 11 by 9 inches to the above quantity of liquid.

45. At firſt a ſlight difficulty may be felt in immerſing them without encloſing air bubbles; the greaſy nature of the ſurface preventing any immediate adheſion of the liquid.

The paper ſhould be held by one end, and then gradually laid down on the ſurface of the bath, commencing at the other end; the paper ought not to ſlant towards the ſurface of the bath, or there will be danger of encloſing air bubbles; but while it is being laid down, the part out of the liquid ſhould be kept as nearly

as poſſible at right angles with the part which is already floating on the ſurface; any curling up of the ſheet when firſt laid down, may be prevented by breathing on it gently. In about ten minutes, the ſheet ought to be lifted up by one corner, and turned over in a ſimilar way; a ſlight agitation of the diſh will then throw the liquid entirely over that ſheet, and another can be treated in like manner.

Before the ſheets have been in this bath many minutes, the iodine, uniting with the ſtarch with which the paper is ſized, will have turned them to ſuch a deep purple colour as to appear almoſt black.

46. They muſt remain ſoaking for three or four hours; ſeveral times during that interval, (and eſpecially if there be many ſheets in the ſame bath,) they ought to be moved about and turned over ſingly, to allow of the liquid penetrating between them, and coming perfectly in contact with every part of the ſurface. After they have ſoaked for a ſufficient time, the ſheets ſhould be taken out and hung up to dry; this is conveniently effected by ſtretching a ſtring acroſs the room, and hooking the papers on to this by means of a large

ſized pin (known as *blanket* pin) bent into the ſhape of the letter S. The point of the pin ſhould be run through one corner of the paper and then the head hooked over the ſtretched line.

After a ſheet has been hung up for a few minutes, a piece of blotting paper, about one inch ſquare, ſhould be ſtuck to the bottom corner to abſorb the drop, and prevent its drying on the ſheet, or it would cauſe a ſtain in the picture.

47. While the ſheets are drying, they ſhould be looked at occaſionally, and the way in which the liquid on the ſurface dries, noticed; if it collect in large drops over the ſurface, it is a ſign that the ſheets have not been ſufficiently acted on by the iodizing bath, or have been removed from the latter too ſoon; and if, when looked through, they are not of a uniform deep purple colour, but clouded and uneven, it ſhows that there has been ſome irregular abſorption of the wax, or defect in the iodizing: it will be as well to reject ſheets ſo marked.

48. As ſoon as the ſheets are quite dry, they can be put aſide in a box for uſe at a

future time. There is a great deal of uncertainty as regards the length of time the ſheets may be kept in this ſtate without ſpoiling; I can ſpeak from experience as to there having been no ſenſible deterioration after a lapſe of ten months, but further than this I have not tried.

Up to this ſtage, it is immaterial whether the operations have been performed by daylight or not; but the ſubſequent treatment, until the fixing of the picture, muſt be done by yellow light (8).

EXCITING.

THE next ſtep conſiſts in rendering the iodized paper ſenſitive to light. Although, when extreme care is taken in this operation, it is hardly of any conſequence when this is performed; yet in practice, it will not be found convenient to *excite* the paper earlier than about a fortnight before its being required for uſe.

The materials for the exciting bath are nitrate of ſilver, glacial acetic acid, and water. It is of little importance what be the ſtrength of the ſolution of nitrate of ſilver; the diſadvantages of a weak ſolution are, that the ſheets require to remain in contact with it for a conſiderable time before the decompoſition is effected, and the bath requires oftener renewing; while with a bath which is too ſtrong, time is equally loſt in the long-continued waſhing

requiſite to enable the paper to keep good for any length of time. The quantity of acetic acid is alſo of little conſequence.

50. In the following bath, I have endeavoured ſo to adjuſt the proportion of nitrate of ſilver, as to avoid as much as poſſible both the inconveniences mentioned above,

Nitrate of ſilver	.	300 grains.
Glacial acetic acid	.	120 grains.
Diſtilled water	.	20 ounces.

The nitrate of ſilver and acetic acid are to be added to the water, and when diſſolved, filtered into a clean diſh (12), taking care that the bottom of the diſh be flat, and that the liquid cover it to the depth of at leaſt half an inch all over; by the ſide of this, two ſimilar diſhes muſt be placed, each containing diſtilled water.

51. A ſheet of iodized paper is to be taken by one end, and gradually lowered (45), the marked ſide downwards, on to the exciting ſolution, taking care that no liquid gets on to the back, and no air bubbles are encloſed. It will be neceſſary for the ſheet to remain on this bath from five to ten minutes; but it can generally be known when the operation

is completed by the change in appearance, the purple colour entirely diſappearing, and the ſheet aſſuming a pale, homogeneous ſtraw colour.

52. When this is the caſe, one corner of it muſt be raiſed up by the platinum ſpatula, lifted out of the diſh with rather a quick movement, allowed to drain for about half a minute, and then floated on the ſurface of the water in the ſecond diſh, while another iodized ſheet is placed on the nitrate of ſilver ſolution; when this has remained on for a ſufficient time, it muſt be in like manner tranſferred to the diſh of diſtilled water, having removed the previous ſheet to the next diſh.

53. A third iodized ſheet can now be excited, and when this is completed, the one firſt excited muſt be perfectly dried by preſſing between folds of clean blotting paper (21), wrapped up in clean paper, and preſerved in a portfolio until required for uſe; and the others can be transferred a diſh forward, as before, taking care that each ſheet be waſhed twice in diſtilled water, and that at every fourth ſheet the diſhes of waſhing water be emptied, and repleniſhed with clean diſtilled

water; this water ſhould not be thrown away, but preſerved in a bottle for a ſubſequent operation (63).

54. The above quantity of the exciting bath, will be found quite enough to excite about thirty ſheets of the ſize 11 × 9 inches, or 3000 ſquare inches of paper. After the bulk has been exhauſted for this purpoſe it ſhould be kept, like the waſhing waters, for the ſubſequent operation of developing (63).

Of courſe theſe ſenſitive ſheets muſt be kept in perfect darkneſs. Generally, ſufficient attention is not paid to this point. It ſhould be borne in mind, that an amount of white light, quite harmleſs if the paper were only expoſed to its action for a few minutes, will infallibly deſtroy it if allowed to have acceſs to it for any length of time; therefore, the longer the ſheets are required to be kept, the more carefully muſt the light, even from gas, be excluded; they muſt likewiſe be kept away from any fumes or vapour.

EXPOSING IN THE CAMERA.

VERY few rules can be given for regulating the time of expoſure in the camera; the operator muſt rely on his own experience, which will not be too dearly bought with the ſacrifice of the firſt two or three pictures. With a Roſs' three inch landſcape lens and half-inch ſtop, I ſhould expoſe for between five and ten minutes on a bright day without much ſun.

I prefer to employ as much as poſſible the ſame ſized diaphragm (half an inch will be found a very good aperture for a lens of 12 or 14 inches focus), as then, the light which enters the camera being tolerably uniform for equally bright days the time of expoſure can be better regulated.

56. On account of the iodizing bath being

of ſuch a ſimple compoſition the time of expoſure will bear varying within extremely wide limits without much interfering with the ultimate beauty of the negative. Thus, under the circumſtances mentioned above, an expoſure of either three or twenty minutes would equally have given a picture, and, by care and attention during the development, neither of them would have been much inferior to one which had received the proper time of expoſure.

57. It is a curious fact, and one which I have frequently found uſeful, that when the ſenſitive ſurface conſiſts of iodide of ſilver, and objects are being copied which preſent great contraſts of light and ſhade; the photographic effect of the light radiated from the faintly illuminated objects, will increaſe in a much greater ratio than the effect from the brighter objects. Thus, after a very ſhort expoſure, only the brighter parts will be ſeen on developing; if the expoſure be longer, there will be a ſtage at which the relative intenſities of light and ſhade are true to nature: and by ſtill more prolonging the expoſure, the difference between the light and dark parts of the picture will become leſs and leſs, until

ultimately they will meet in one uniform opaque black.

58. It is both intereſting and inſtructive to look over a collection of photographs and notice the differences between one picture and another as regards expoſure. Alas! for the patience of photographers: upwards of eighty per cent will ſhow unmiſtakable ſigns of being under expoſed, whilſt thoſe which have been over expoſed will be but a very ſmall fraction of the remainder.

59. In ſkilful hands a knowledge of theſe facts may often be turned to great advantage. Slight under expoſure, ſufficient to produce a trifling exaggeration in the contraſt of light and ſhade, without, however, loſing all detail in the ſhadows, adds conſiderably to the vigour and artiſtic beauty of the picture, and may frequently, and not unjuſtifiably, be reſorted to in the abſence of ſunſhine. Whilſt for copying maſſes of foliage or other photographically dark objects, acquaintance with the effect of over expoſure, will often, with judgment, be found uſeful in obtaining a correct repreſentation of the viſible variations in light and ſhade; for although iodide of ſilver

is not ſenſitive to green light, ſtill on analyſing with a priſm the light reflected from maſſes of vegetation, I have found it to be far from homogeneous, there being in every caſe ſufficient active rays preſent to affect this ſenſitive compound.

DEVELOPING.

UNLESS the expoſure to light has been extremely long, nothing will be viſible on the ſheet after its removal from the camera, more than there was previous to expoſure; the action of the light merely producing a latent impreſſion, which requires to be *developed* to render it viſible.

61. The developing bath in every caſe conſiſts of an aqueous ſolution of gallic acid, with the addition, more or leſs, of a ſolution of nitrate of ſilver.

An improvement on the ordinary method of developing with gallic acid, formed the ſubject of a communication to the Philoſophical Magazine for March 1855, where I recommend the employment of a ſtrong alco-

holic ſolution of gallic acid, to be diluted with water when required for uſe, as being more economical both of time and trouble than the preparation of a large quantity of an aqueous ſolution for each operation.

62. The ſolution is thus made: put two ounces of cryſtallized gallic acid into a dry flaſk with a narrow neck; over this pour ſix ounces of good alcohol, (60° over proof,) and place the flaſk in hot water until the acid is diſſolved, or nearly ſo. This will not take long, eſpecially if it be well ſhaken once or twice. Allow it to cool, then add half a drachm of glacial acetic acid, and filter the whole into a ſtoppered bottle.

63. To obtain a ſolution of about the ſame ſtrength as a ſaturated aqueous ſolution, half a drachm of the above would require to be added to two ounces of water, but for this purpoſe I prefer a weaker bath, which is prepared by mixing together five ounces of the water that has been previouſly uſed for waſhing the excited papers (53), and four drachms of the exhauſted exciting bath (54); the mixture is then to be filtered into a perfectly clean diſh, and half a drachm of the above

alcholic ſolution of gallic acid poured into it. The above quantities are ſufficient to develop one ſheet of the ſize 11 × 9 inches.

64. The diſh muſt be ſhaken about until the greaſy appearance has quite gone from the ſurface; and then the ſheet of paper may be laid down on the ſolution in the ordinary manner, with the marked ſide downwards, taking particular care that none of the ſolution gets on the back of the paper, or it will cauſe a ſtain. Should this happen, either wipe it off carefully with blotting paper, or immerſe the ſheet entirely in the liquid.

65. If the paper has been expoſed to a moderate light, the picture will begin to appear within five minutes of its being laid on the ſolution, and will be finiſhed in an hour. It may however ſometimes be requiſite, if the light has been feeble, to prolong the development for a day or more. If the diſh be perfectly clean, the developing ſolution will remain active for the whole of this time; and when uſed only for a few hours, will be quite clear and colourleſs, or with the fainteſt tinge of brown; a darker appearance indicates the preſence of dirt. The progreſs of the de-

velopment may be watched, by gently raiſing one corner with the platinum ſpatula, and lifting the ſheet up by the fingers. This ſhould not be done too often, as there is always a riſk of producing ſtains on the ſurface of the picture. I prefer allowing the development to go on, until the colour is rather more intenſe than is ultimately required, as it is generally toned down in the fixing bath.

66. According to the behaviour of the picture in this bath, the operator can judge of the kind of expoſure that it has received.

If the ſheet has been expoſed for an inſufficient time the picture will be tardy in making its appearance, and then only the brighter parts of the object will be rendered viſible. Long continued development will ſeldom have any other effect than increaſing the opacity of theſe parts, the objects which are at all in ſhadow remaining permanently inviſible. There will be a nearly total abſence of half tint, and the ſheet will generally appear remarkably clean, while the diviſion between opaque black and clear white will be abrupt and ſharp.

67. The appearance of an over expoſed

ſheet is nearly the converſe of the above. The picture makes its appearance very rapidly, and at firſt ſeems to promiſe a good negative; all the detail, even of objects in deep ſhadow, being ſoon viſible. Gradually, however, a miſt ſeems to come over thoſe parts which ought to remain tranſparent, and then the light parts begin to get darker and darker, without a correſponding deepening in intenſity of the dark parts, until, as noticed above (57), the diſtinction between light and ſhade is nearly loſt.

68. The development of a ſheet which has been expoſed for the proper time is nearly intermediate in appearance between that of under and over expoſure. The high lights make their appearance firſt; very ſoon after they are followed by the next ſtrongly illuminated objects, and then by all the other parts in the order of their brightneſs. The relative intenſities of light and ſhade are always truly preſerved (inverſely of courſe) and the darkening goes on increaſing regularly and quickly.

69. As ſoon as the picture is judged to be ſufficiently intenſe, it muſt be removed from

the gallo-nitrate, and laid on a diſh of water, (not neceſſarily diſtilled). In this ſtate it may remain until the final operation of fixing: this need not be performed immediately, if inconvenient, as after being waſhed once or twice, and dried between clean blotting paper, the picture will remain unharmed for weeks, if kept in a dark place.

FIXING.

THE *fixing bath* is compoſed of a ſaturated ſolution of hypoſulphite of ſoda diluted with its own bulk of water. Into this the ſheets are to be completely immerſed, until the whole of the yellow iodide of ſilver has been diſſolved out. This operation need not be performed by yellow light; daylight is much better for ſhowing whether the picture be entirely fixed. This will take from a quarter of an hour to two hours, according to the time the bath has been in uſe.

It will be well not to put too many ſheets into the bath at once, in order to avoid the neceſſity of turning them over to allow the liquid to penetrate every part.

When fixed, the ſheet, if held up between the light and the eye, will preſent a clear ſemi-tranſparent appearance in the white parts.

The fixing bath gradually becomes leſs and leſs active by uſe, and then its action is very energetic on the dark parts of the picture, attacking and diſſolving them almoſt as much as the unchanged iodide. When this is the caſe it ſhould be put on one ſide, and a freſh bath made.

71. After removal from the fixing bath, the ſheets muſt be well waſhed. In this operation, the effect depends more upon the quantity of water uſed, than upon the duration of the immerſion. When practicable, it is a good plan to allow water from a tap to flow over each ſide of the ſheets for a minute or two, and having thus got rid of the hypoſulphite of ſoda from the ſurface, to allow them to ſoak for half an hour in two or three changes of warm water, and laſtly, for about ten minutes in a large diſh of hot water.

72. They are then to be dried by hanging up by a crooked pin, as after iodizing (46). When dry, they will preſent a very rough and granular appearance in the tranſparent parts;

this is removed by melting the wax, either before a fire, or, what is far better, by placing the ſheets between blotting paper, and paſſing a warm iron over them; by this means, the white parts will recover their original tranſparency.

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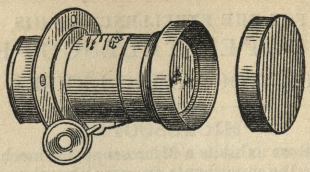

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